Absorptiemetingen aan 30 boorkernen

M+P.DWW.04.2.1

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1 INLEIDING

In opdracht van de Dienst Weg- en Waterbouwkunde van het Ministerie van Verkeer en Waterstaat is door M+P Raadgevende ingenieurs bv een onderzoek uitgevoerd naar de geluidabsorberende eigenschappen van 30 boorkernen. Aan de boorkernen zijn absorptiemetingen verricht in een impedantie buis volgens ISO 10534-1 [1]. Tevens is van de boorkernen het percentage toegankelijk holle ruimte vastgesteld.

In het onderhavige rapport zijn de resultaten van de absorptiemetingen en de metingen van het percentage toegankelijke holle ruimte weergegeven.

2 BOORKERNEN

In tabel I is een overzicht van de 30 boorkernen gegeven. Per boorkern staat de codering vermeldt evenals de dikte van de toplaag en onderlaag. Van iedere boorkern staat ook een foto afgebeeld.

tabel I *Overzicht van de codering en laagdikten van de 30 boorkernen. (De afmetingen van een blokje op het raster bij de foto zijn 1 x 1 cm)*

codering	dikte [mm]		foto
	toplaag	onderlaag	
TWE002	20-22	60-62	
TWE003	18-25	57-65	
TWE007	20-24	50-52	
TWE008	18-25	60	
TWE012	20-22	55-58	
TWE013	20-25	60	

codering	dikte [mm]		foto
	toplaag	onderlaag	
TWE014	20-28	57	
TWE016	17-25	55-57	
TWE018	30-32	50-54	
TWE020	18-20	60	
TWE023	30-35	55	
TWE024	20-25	60	
TWE028	18-20	60	
TWE029	20-25	55	

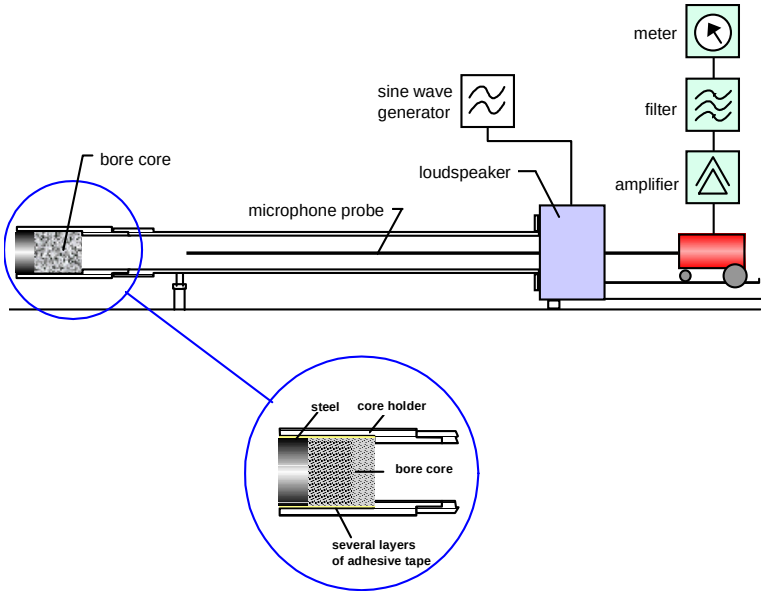
codering	dikte [mm]		foto
	toplaag	onderlaag	
TWE031	30-31	50-53	
TWE034	18-25	60	
TWE036	20-24	50-55	
TWE037	20-25	50-56	
TWE038	20-23	60-64	
TWE040	19-24	60-63	
TWE043	20-24	56-58	
TWE045	21-24	63	

codering	dikte [mm]		foto
	toplaag	onderlaag	
TWE046	30-32	54-55	
TWE048	30-32	58-60	
TWE049	18-23	57-62	
TWE050	30	62	
TWE052	18-22	65-68	
TWE056	17-22	65-68	
TWE061	19-25	58-65	
TWE066	17-23	52-56	

3 EXPERIMENTELE OPZET

3.1 Absorptiemetingen met behulp van de impedantie buis

De akoestische absorptie van de boorkernen is bepaald volgens ISO 10534-1 [1]. Een principeschets van de meetopstelling is weergegeven in figuur 1.



figuur 1 *Meetopstelling voor het meten van de akoestische absorptie van proefstukken volgens ISO 10534-1*

Een proefstuk met een diameter van 10 cm wordt luchtdicht afgesloten in een impedantie buis geplaatst. Met behulp van een luidspreker gevoed met zuivere tonen worden in de buis staande golven opgewekt. De drukmaxima p_{max} en drukminima p_{min} in de buis worden gemeten met een microfoon die verplaatsbaar is in de lengterichting van de buis. Aan de hand van de standing wave ratio (SWR), dit is de verhouding tussen de maxima en minima, wordt bij verschillende frequenties de absorptiecoëfficiënt α van het proefstuk bepaald.

$$\alpha = \frac{4}{SWR + \frac{1}{SWR} + 2} \qquad 3.1$$

met:

$$SWR = \frac{p_{max}}{p_{min}} \qquad 3.2$$

Het frequentiebereik van de meetmethode strekt van 125 Hz tot en met 2000 Hz.

Bij de metingen is gebruik gemaakt van de in tabel II gebruikte apparatuur.

tabel II *Overzicht van de gebruikte meetapparatuur*

	fabrikant	type
standing wave apparatus	B&K	4002
sinustoongenerator	KENWOOD	AG-203
power amplifier	QUAD	50
1/3 octaaf filterset	B&K	1612
microfoonversterker	B&K	2603

3.2 Bepaling van het percentage toegankelijke holle ruimte

De akoestische absorptie eigenschappen van een wegdek (en poreuze materialen in het algemeen) worden voor een belangrijk deel bepaald door de hoeveelheid holle ruimte in het materiaal die toegankelijk is voor het geluid dat op het oppervlak van het materiaal invalt. Holle ruimten die volledig omsloten zijn, en derhalve niet toegankelijk zijn, zijn akoestisch gezien niet interessant. Het percentage *toegankelijke* holle ruimte van een proefstuk kan bepaald worden door het proefstuk in een maatbeker met water te dompelen. Aan de hand van de volumeverandering in de maatbeker en de afmetingen van het proefstuk kan vervolgens het percentage *toegankelijke* holle ruimte vastgesteld worden volgens:

$$\%HR = 100 \cdot \left(1 - \frac{V_{na} - V_{voor}}{d \cdot \pi \cdot r^2} \right) \qquad 3.3$$

met:
V_{na} : volume in maatbeker na onderdompelen
V_{voor} : volume in maatbeker voor onderdompelen
d : dikte proefstuk
r : straal proefstuk

4 RESULTATEN

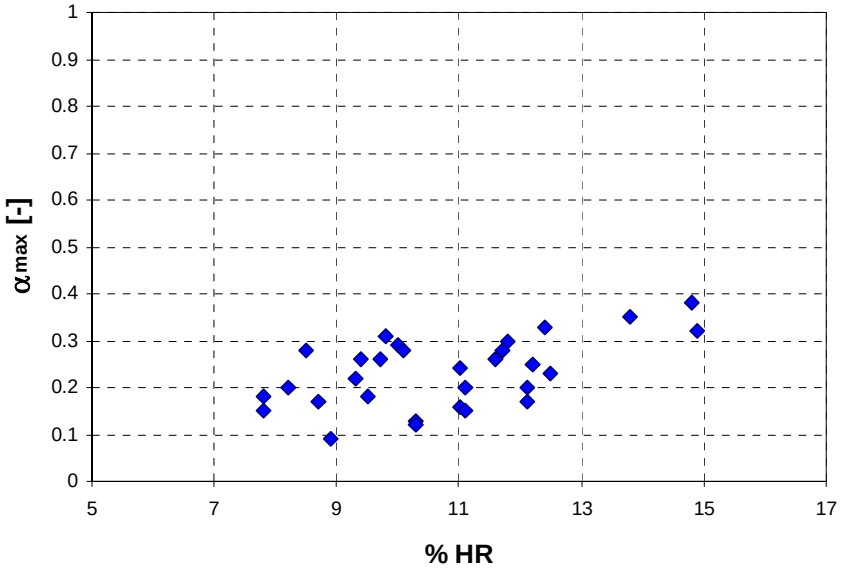
De resultaten van de absorptiemetingen met de impedantie buis en de resultaten van de metingen van het percentage toegankelijke holle ruimte voor de 30 boorkernen zijn weergegeven in de bijlage. In tabel III (p.11) is een samenvattend overzicht gegeven. Hierin staan voor iedere boorkern de absorptiekentallen en het percentage toegankelijke holle ruimte weergegeven. De absorptiekentallen zijn gedefinieerd als:

- $f_{\alpha max}$ [Hz], de frequentie waarbij het eerste absorptiemaximum optreedt;
- α_{max} [-], de bijbehorende maximale absorptiecoëfficiënt.

tabel III *Samenvatting absorptiekentallen en percentage toegankelijke holle ruimte per boorkern*

boorkern	absorptiekentallen		% HR
	α_{max} [-]	$f_{\alpha,max}$ [Hz]	
TWE002	0,23	234	12,5
TWE003	0,26	258	9,4
TWE007	0,29	258	10,0
TWE008	0,26	258	11,6
TWE012	0,16	258	11,0
TWE013	0,20	234	11,1
TWE014	0,13	340	10,3
TWE016	0,18	258	7,8
TWE018	0,33	281	12,4
TWE020	0,20	234	8,2
TWE023	0,35	281	13,8
TWE024	0,20	234	12,1
TWE028	0,28	281	11,7
TWE029	0,31	293	9,8
TWE031	0,25	281	12,2
TWE034	0,26	234	9,7
TWE036	0,15	258	7,8
TWE037	0,12	340	10,3
TWE038	0,18	211	9,5
TWE040	0,09	340	8,9
TWE043	0,30	258	11,8
TWE045	0,24	281	11,0
TWE046	0,17	211	12,1
TWE048	0,32	234	14,9
TWE049	0,28	258	8,5
TWE050	0,38	223	14,8
TWE052	0,17	211	8,7
TWE056	0,15	211	11,1
TWE061	0,22	340	9,3
TWE066	0,28	258	10,1

In figuur 2 is de α_{max} [-] uitgezet als functie van het percentage toegankelijke holle ruimte.



figuur 2 α_{max} *als functie van het percentage toegankelijke holle ruimte*

In principe geldt hoe hoger het percentage toegankelijke holle ruimte, des te hoger en breder de piek in het absorptiespectrum is en des te hoger de te behalen reductie door absorptie is. De verhoging van het percentage toegankelijke holle ruimte mag echter niet ten koste gaan van de textuur.

5 LITERATUUR

[1] ISO 10534-1: Acoustics – Determination of sound absorption coefficient and impedance in impedance tubes – Part 1: Method using standing wave ratio, 12-1996.

BIJLAGE

Meetresultaten 30 boorkernen

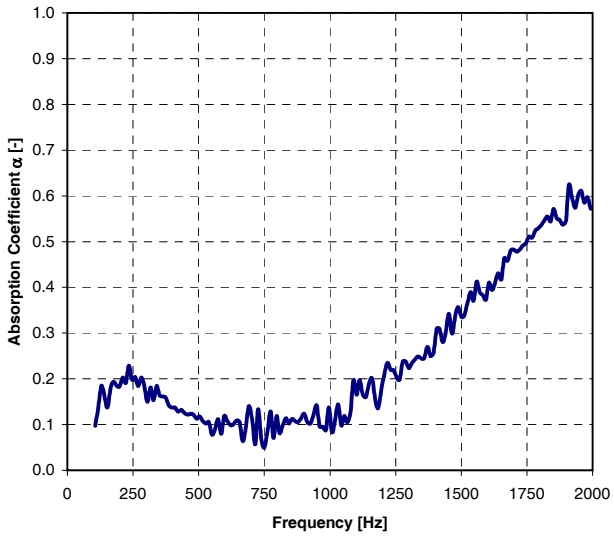
Sound Absorption

ISO 10534-1

Test Sample:	TWE002	
Code:	02022.TWE002	
Total height:	82	mm
Thickness Top Layer:	20-22	mm
Thickness Second Layer:	60-62	mm
Porosity:	12,5	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

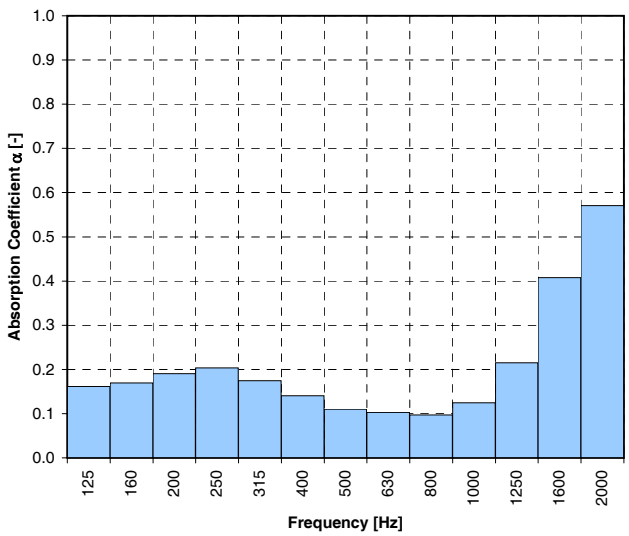
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	234 Hz
α_{max}	0.23

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.20

Sound Absorption of 02022.TWE002

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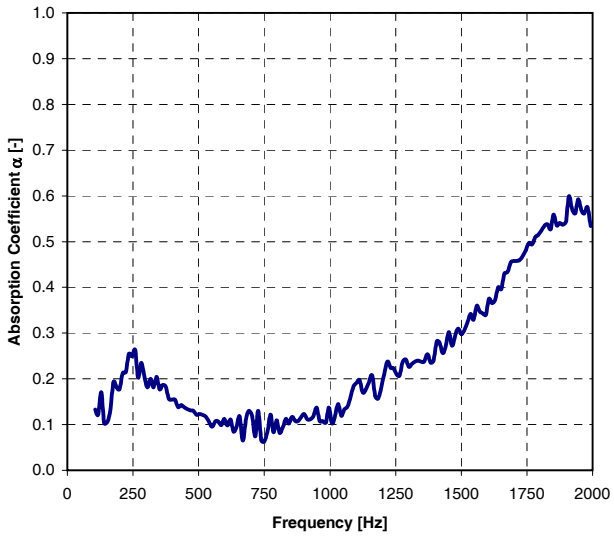
Sound Absorption

ISO 10534-1

Test Sample:	TWE003	
Code:	02022.TWE003	
Total height:	82,5	mm
Thickness Top Layer:	18-25	mm
Thickness Second Layer:	57-65	mm
Porosity:	9,4	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

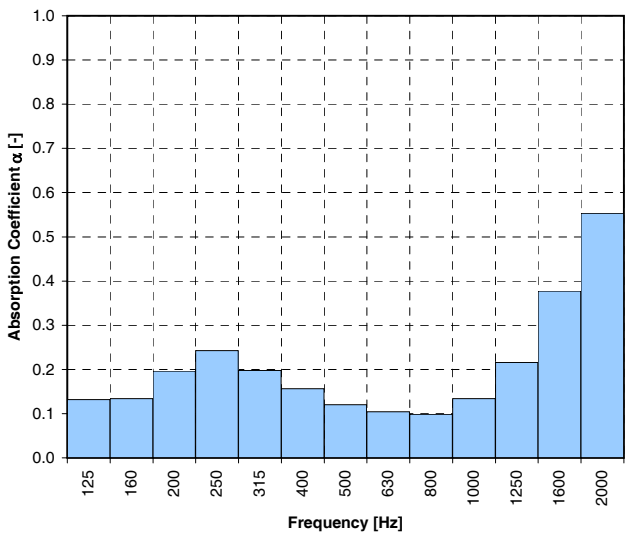
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.26

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.24

Sound Absorption of 02022.TWE003

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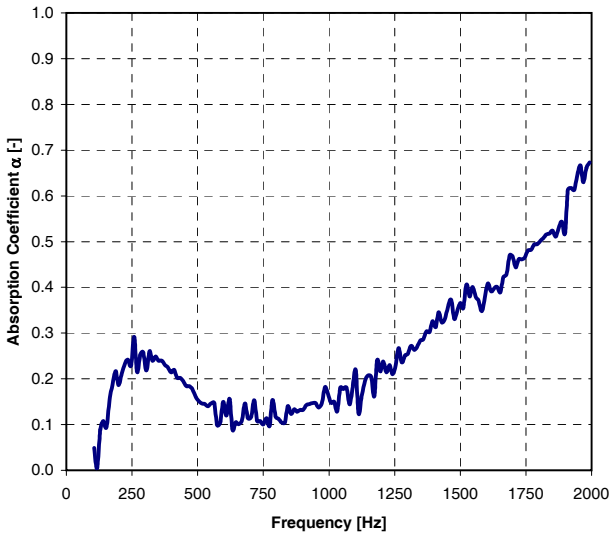
Sound Absorption

ISO 10534-1

Test Sample:	TWE007	
Code:	02022.TWE007	
Total height:	72	mm
Thickness Top Layer:	20-24	mm
Thickness Second Layer:	50-52	mm
Porosity:	10	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

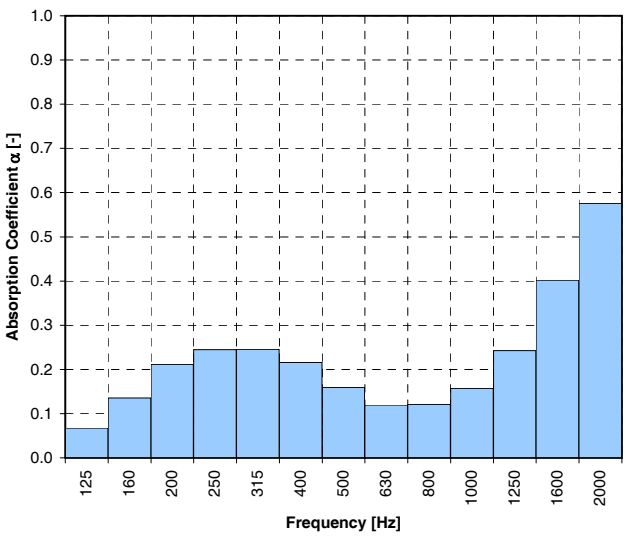
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.29

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	315 Hz
α_{max}	0.25

Sound Absorption of 02022.TWE007

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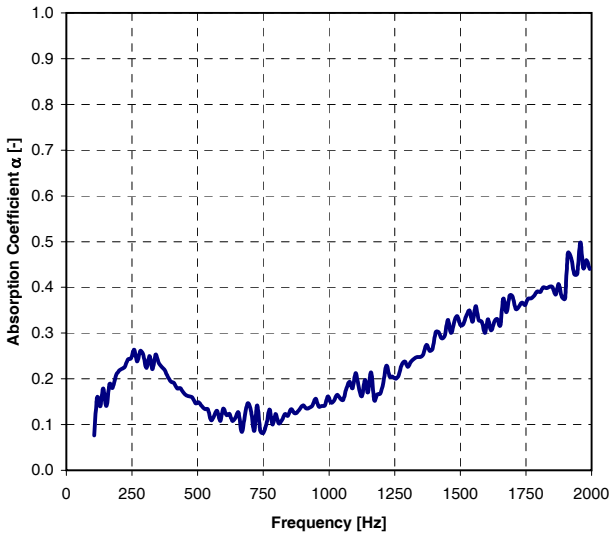
Sound Absorption

ISO 10534-1

Test Sample:	TWE008	
Code:	02022.TWE008	
Total height:	80,5	mm
Thickness Top Layer:	18-25	mm
Thickness Second Layer:	60	mm
Porosity:	11,6	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

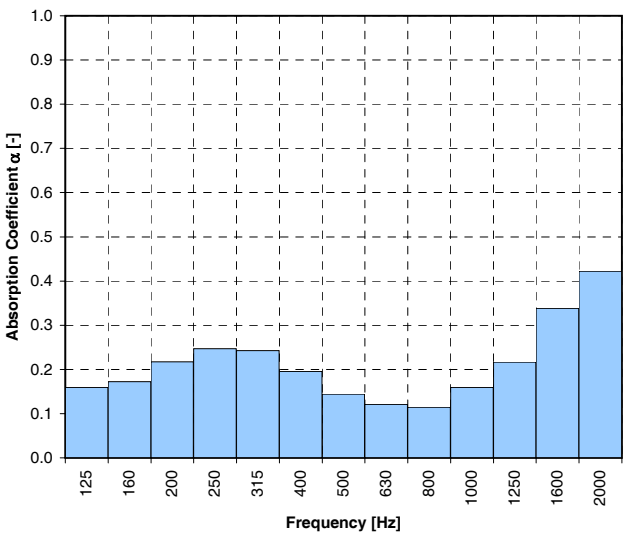
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.26

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.25

Sound Absorption of 02022.TWE008

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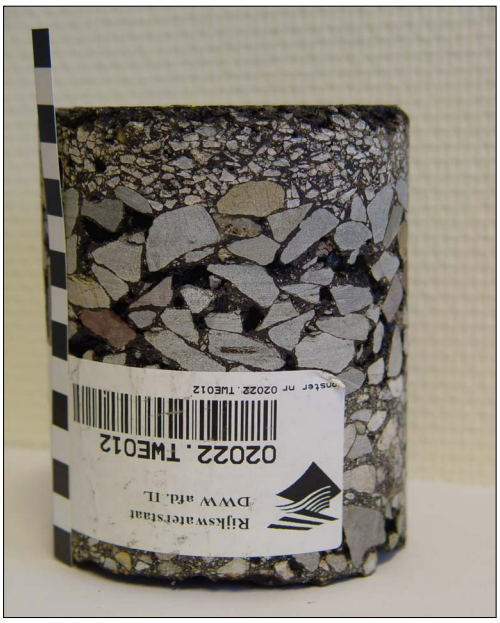
Sound Absorption

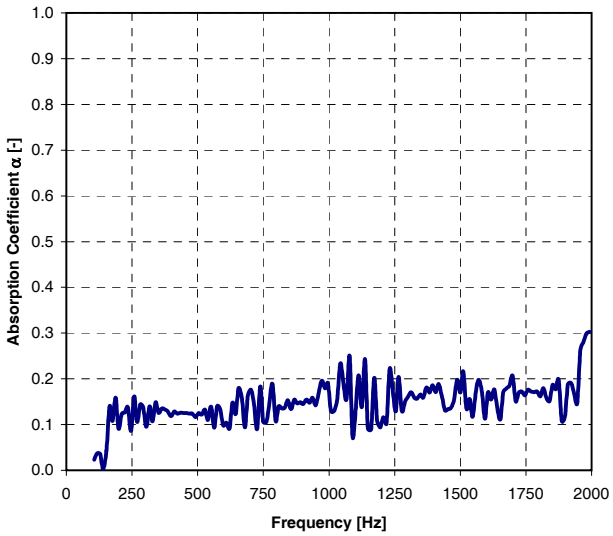
ISO 10534-1



Test Sample:	TWE012	
Code:	02022.TWE012	
Total height:	77	mm
Thickness Top Layer:	20-22	mm
Thickness Second Layer:	55-58	mm
Porosity:	11	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

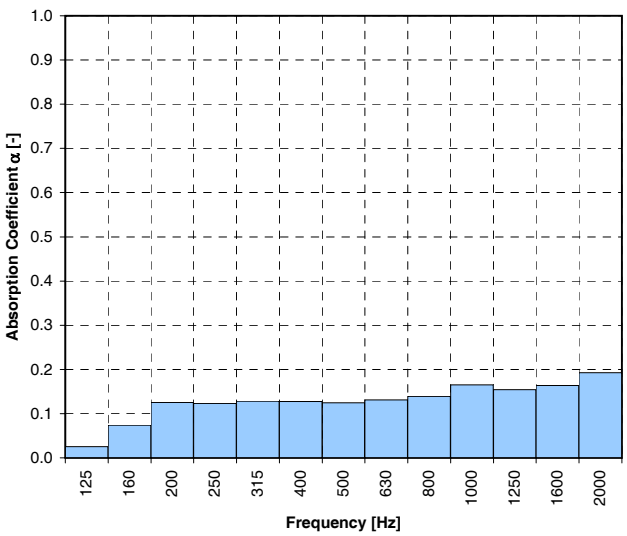
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.16

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	315 Hz
α_{max}	0.13

Sound Absorption of 02022.TWE012

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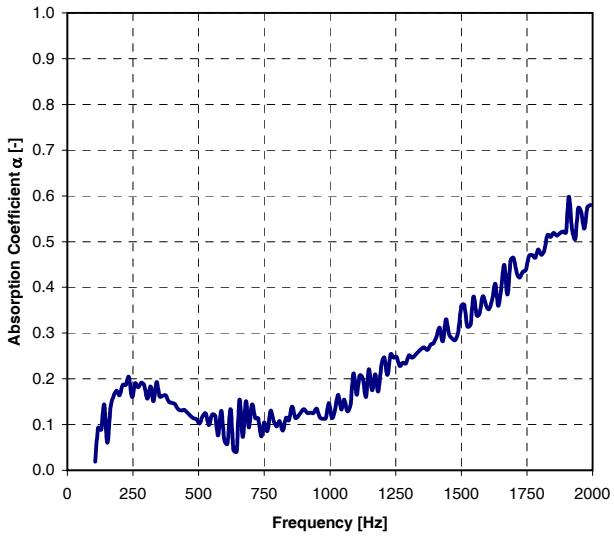
Sound Absorption

ISO 10534-1

Test Sample:	TWE013	
Code:	02022.TWE013	
Total height:	80	mm
Thickness Top Layer:	20-25	mm
Thickness Second Layer:	60	mm
Porosity:	11,1	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

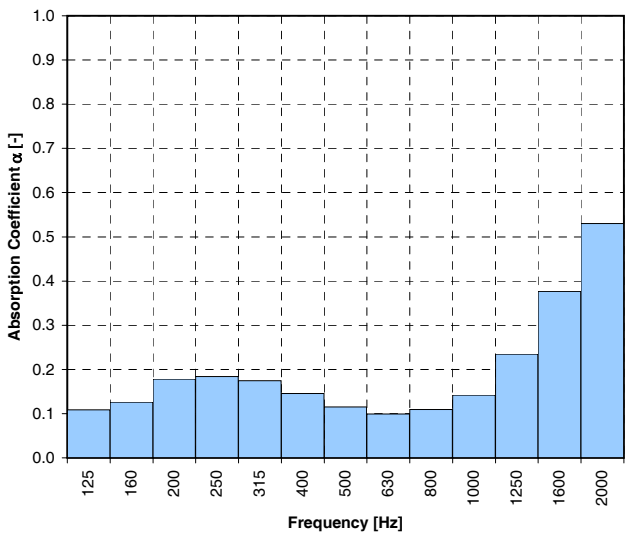
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	234 Hz
α_{max}	0.20

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.18

Sound Absorption of 02022.TWE013

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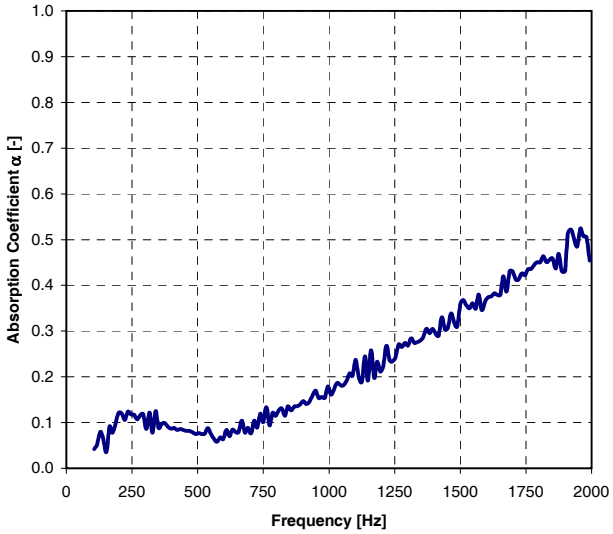
Sound Absorption

ISO 10534-1

Test Sample:	TWE014	
Code:	02022.TWE014	
Total height:	80	mm
Thickness Top Layer:	20-28	mm
Thickness Second Layer:	57	mm
Porosity:	10,3	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

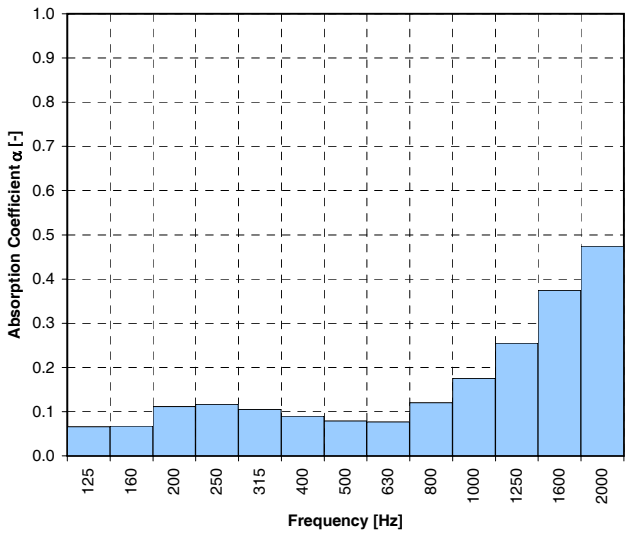
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	340 Hz
α_{max}	0.13

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.12

Sound Absorption of 02022.TWE014

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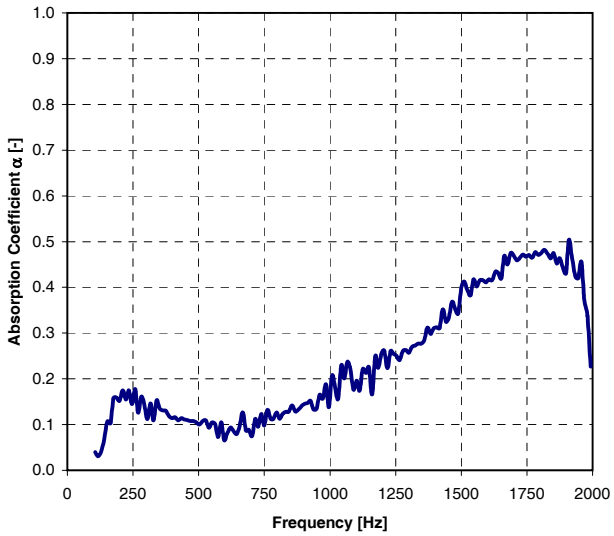
Sound Absorption

ISO 10534-1

Test Sample:	TWE016	
Code:	02022.TWE016	
Total height:	77	mm
Thickness Top Layer:	17-25	mm
Thickness Second Layer:	55-57	mm
Porosity:	7,8	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

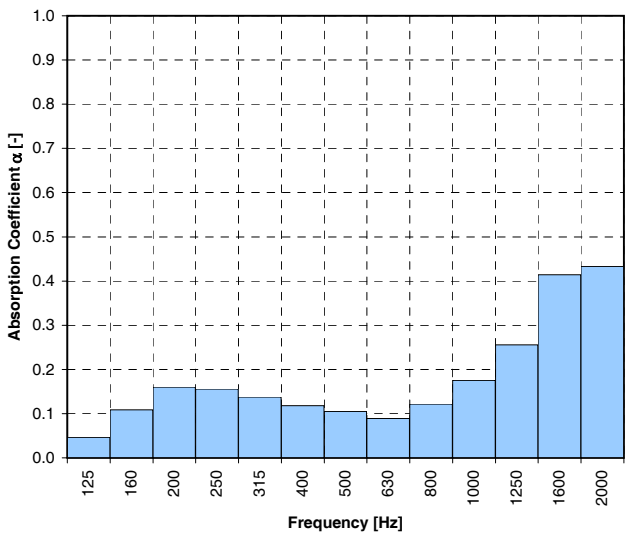
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.18

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.16

Sound Absorption of 02022.TWE016

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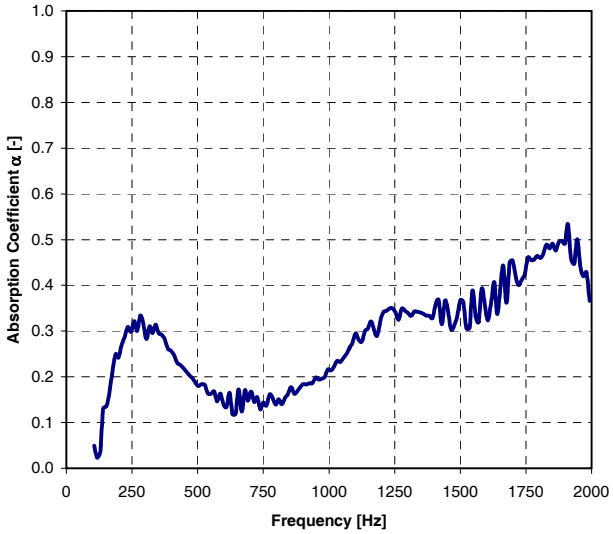
Sound Absorption

ISO 10534-1

Test Sample:	TWE018	
Code:	02022.TWE018	
Total height:	82,5	mm
Thickness Top Layer:	30-32	mm
Thickness Second Layer:	50-54	mm
Porosity:	12,4	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

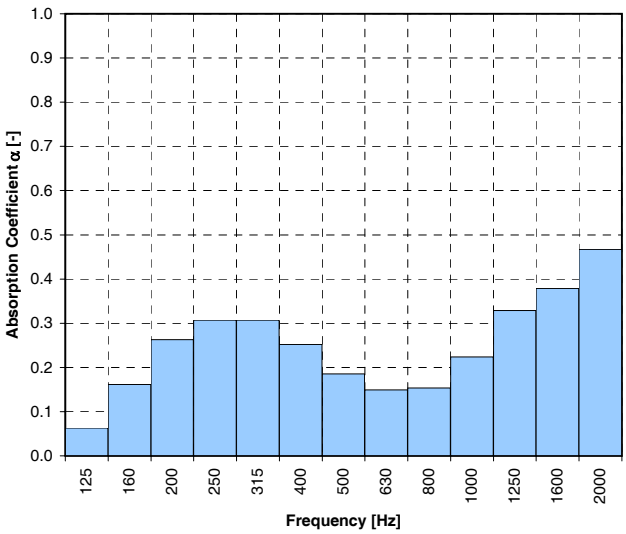
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	281 Hz
α_{max}	0.33

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	315 Hz
α_{max}	0.31

Sound Absorption of 02022.TWE018

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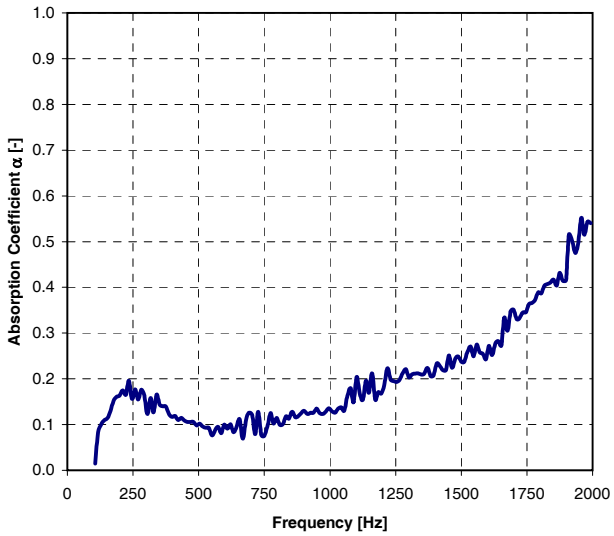
Sound Absorption

ISO 10534-1

Test Sample:	TWE020	
Code:	02022.TWE020	
Total height:	78	mm
Thickness Top Layer:	18-20	mm
Thickness Second Layer:	60	mm
Porosity:	8,2	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

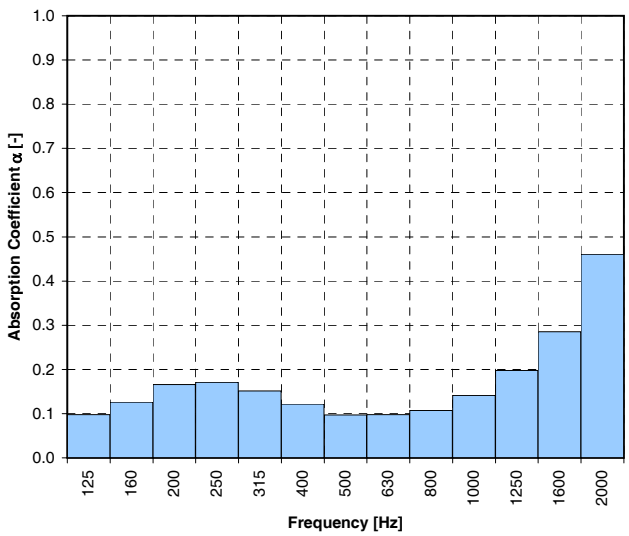
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	234 Hz
α_{max}	0.20

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.17

Sound Absorption of 02022.TWE020

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

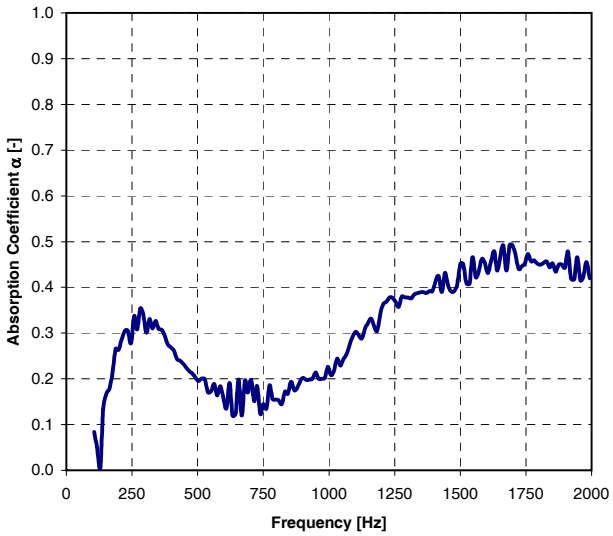
Sound Absorption

ISO 10534-1

Test Sample:	TWE023	
Code:	02022.TWE023	
Total height:	82,5	mm
Thickness Top Layer:	30-35	mm
Thickness Second Layer:	55	mm
Porosity:	13,8	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

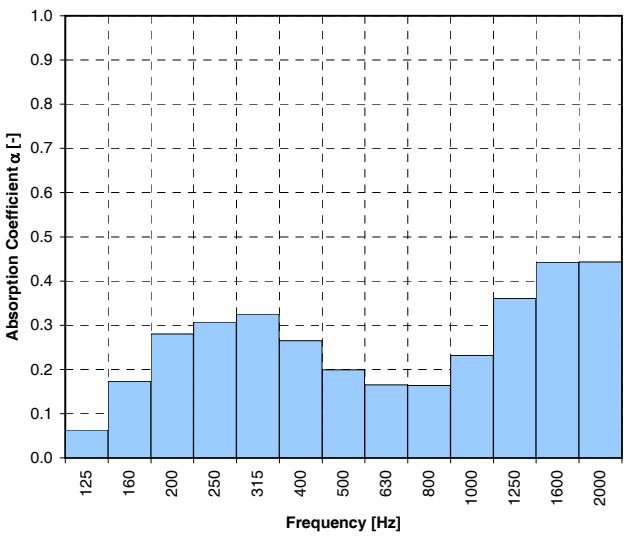
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	281 Hz
α_{max}	0.35

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	315 Hz
α_{max}	0.32

Sound Absorption of 02022.TWE023

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

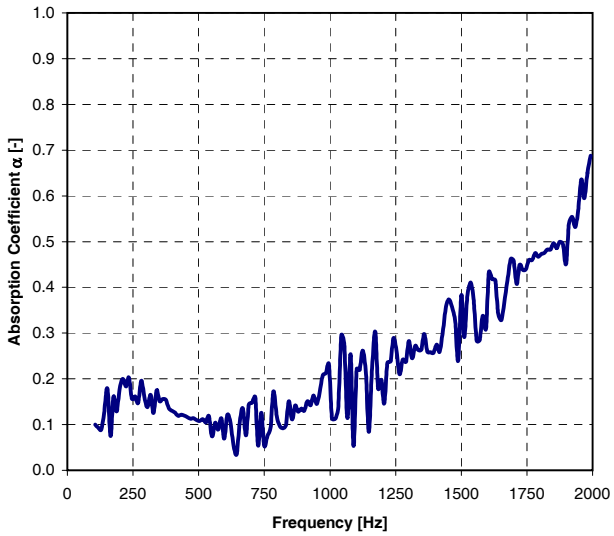
Sound Absorption

ISO 10534-1

Test Sample:	TWE024	
Code:	02022.TWE024	
Total height:	85	mm
Thickness Top Layer:	20-25	mm
Thickness Second Layer:	60	mm
Porosity:	12,1	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

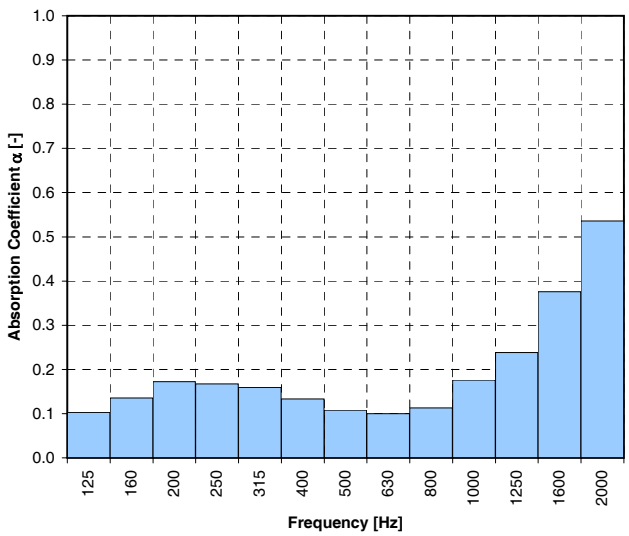
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	234 Hz
α_{max}	0.20

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.17

Sound Absorption of 02022.TWE024

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

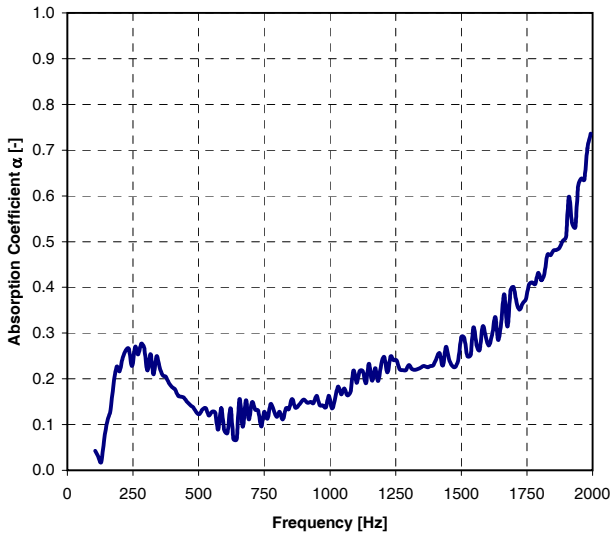
Sound Absorption

ISO 10534-1

Test Sample:	TWE028	
Code:	02022.TWE028	
Total height:	79	mm
Thickness Top Layer:	18-20	mm
Thickness Second Layer:	60	mm
Porosity:	11,7	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

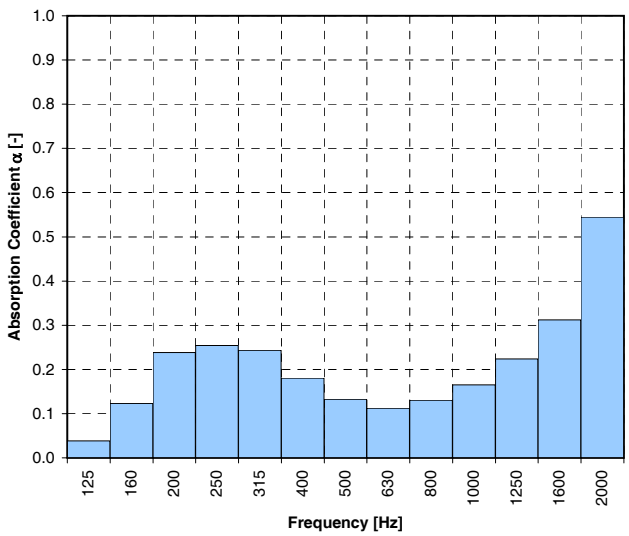
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	281 Hz
α_{max}	0.28

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.25

Sound Absorption of 02022.TWE028

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

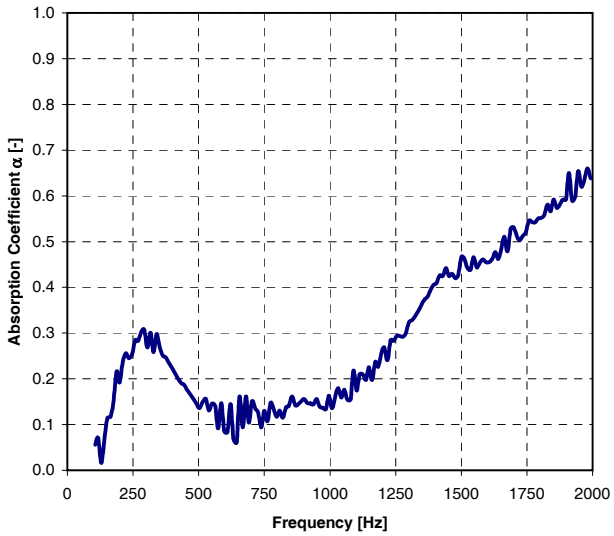
Sound Absorption

ISO 10534-1

Test Sample:	TWE029	
Code:	02022.TWE029	
Total height:	76	mm
Thickness Top Layer:	20-25	mm
Thickness Second Layer:	55	mm
Porosity:	9,8	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

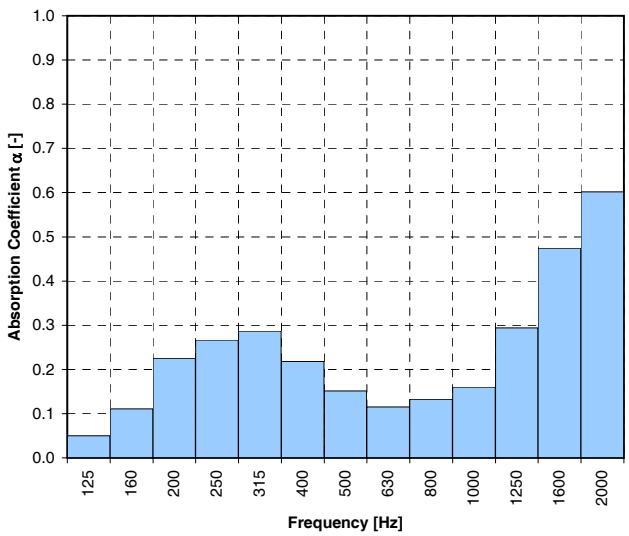
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	293 Hz
α_{max}	0.31

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	315 Hz
α_{max}	0.29

Sound Absorption of 02022.TWE029

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

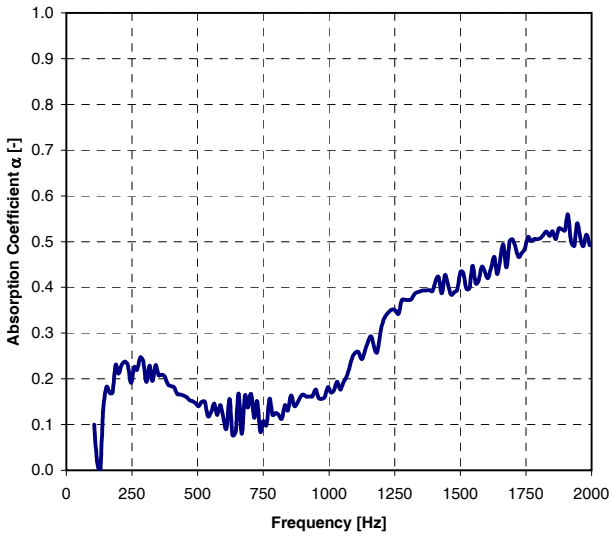
Sound Absorption

ISO 10534-1

Test Sample:	TWE031	
Code:	02022.TWE031	
Total height:	81	mm
Thickness Top Layer:	30-31	mm
Thickness Second Layer:	50-53	mm
Porosity:	12,2	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

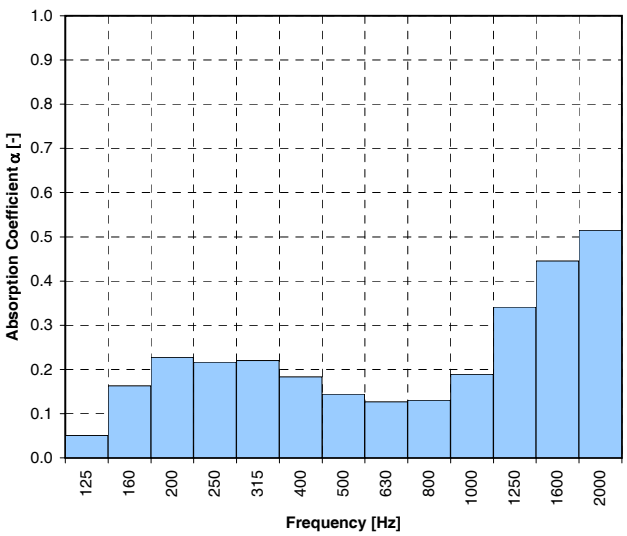
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	281 Hz
α_{max}	0.25

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.23

Sound Absorption of 02022.TWE031

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

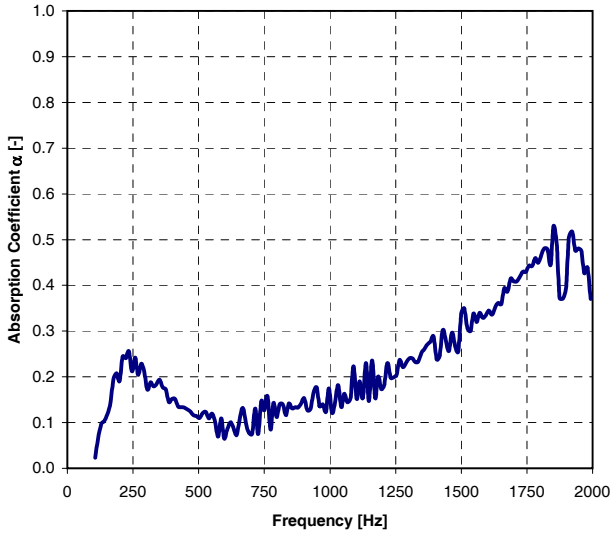
Sound Absorption

ISO 10534-1

Test Sample:	TWE034	
Code:	02022.TWE034	
Total height:	80	mm
Thickness Top Layer:	18-25	mm
Thickness Second Layer:	60	mm
Porosity:	9,7	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

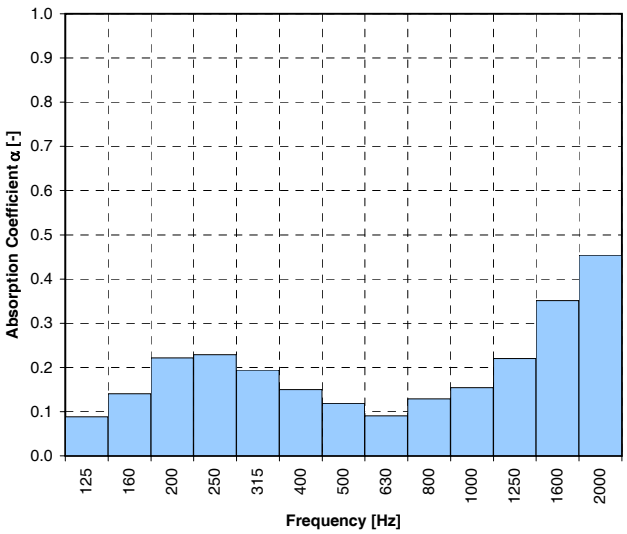
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	234 Hz
α_{max}	0.26

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.23

Sound Absorption of 02022.TWE034

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

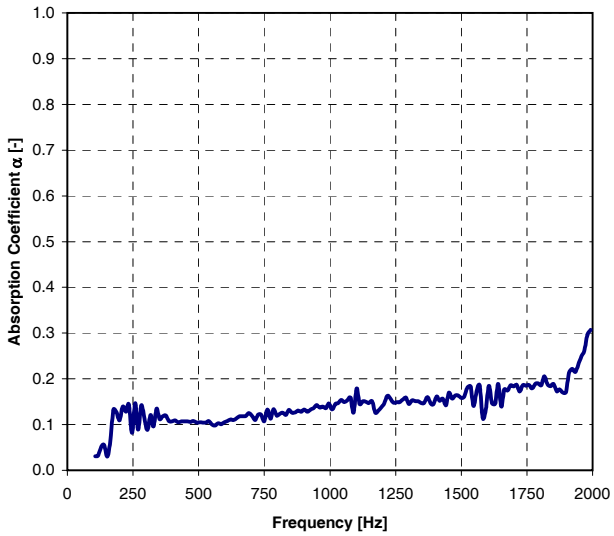
Sound Absorption

ISO 10534-1

Test Sample:	TWE036	
Code:	02022.TWE036	
Total height:	77	mm
Thickness Top Layer:	20-24	mm
Thickness Second Layer:	50-55	mm
Porosity:	7,8	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

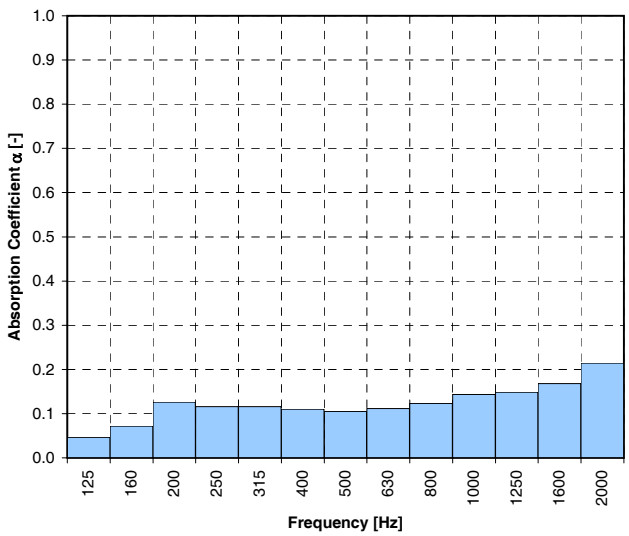
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.15

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.13

Sound Absorption of 02022.TWE036

M+P Raadgevende ingenieurs b.v.

Vught 073-6589050

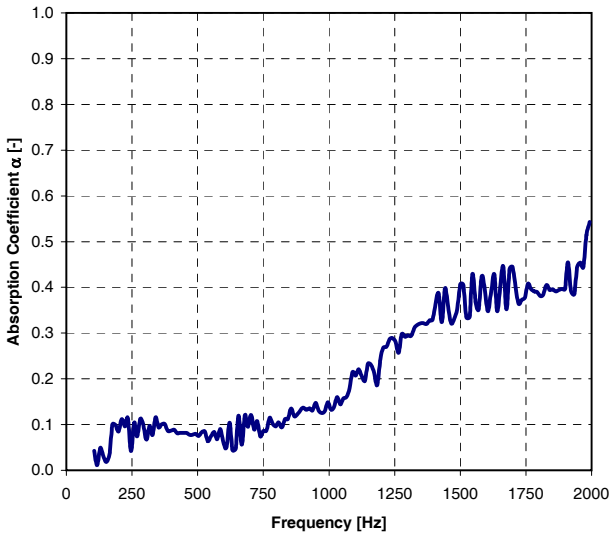
Sound Absorption

ISO 10534-1

Test Sample:	TWE037	
Code:	02022.TWE037	
Total height:	75	mm
Thickness Top Layer:	20-25	mm
Thickness Second Layer:	50-56	mm
Porosity:	10,3	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

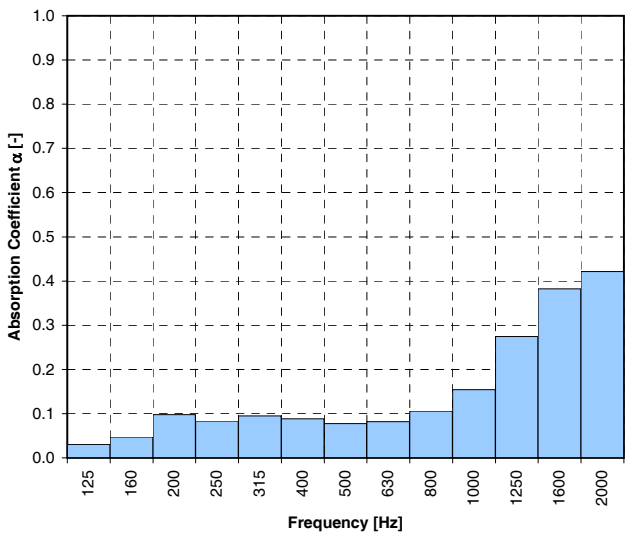
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	340 Hz
α_{max}	0.12

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.10

Sound Absorption of 02022.TWE037

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

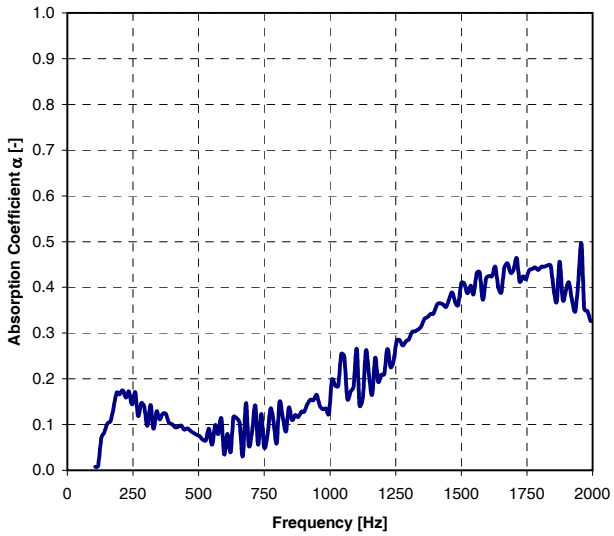
Sound Absorption

ISO 10534-1

Test Sample:	TWE038	
Code:	02022.TWE038	
Total height:	84	mm
Thickness Top Layer:	20-23	mm
Thickness Second Layer:	60-64	mm
Porosity:	9,5	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

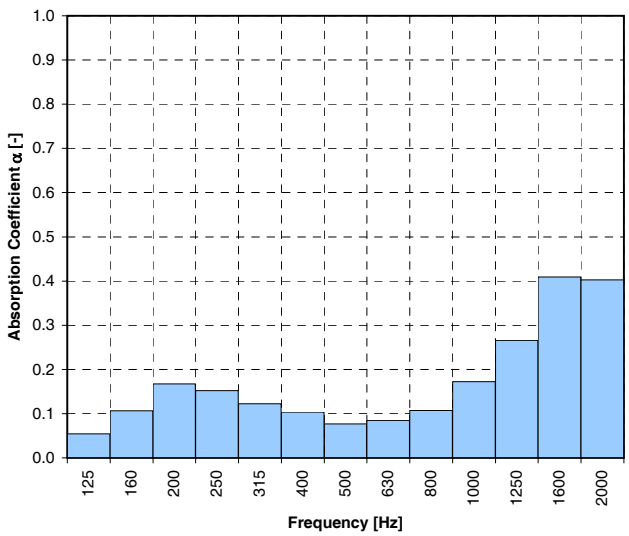
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	211 Hz
α_{max}	0.18

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.17

Sound Absorption of 02022.TWE038

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

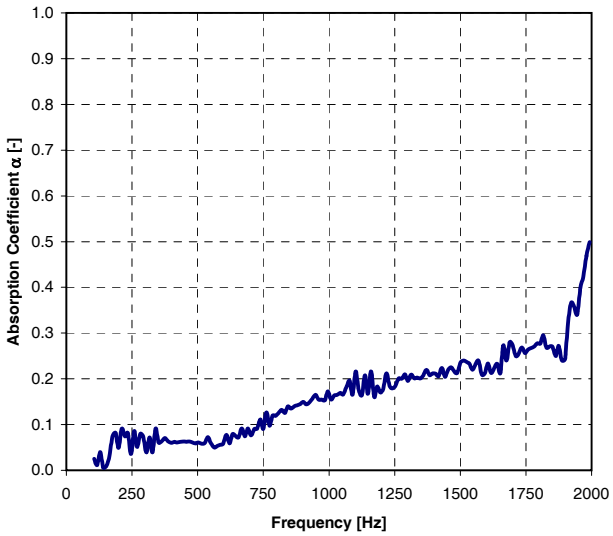
Sound Absorption

ISO 10534-1

Test Sample:	TWE040	
Code:	02022.TWE040	
Total height:	85,5	mm
Thickness Top Layer:	19-24	mm
Thickness Second Layer:	60-63	mm
Porosity:	8,9	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

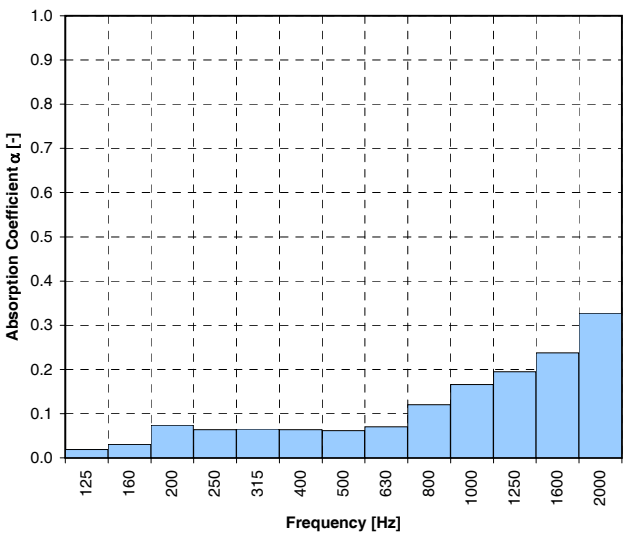
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	340 Hz
α_{max}	0.09

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.07

Sound Absorption of 02022.TWE040

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

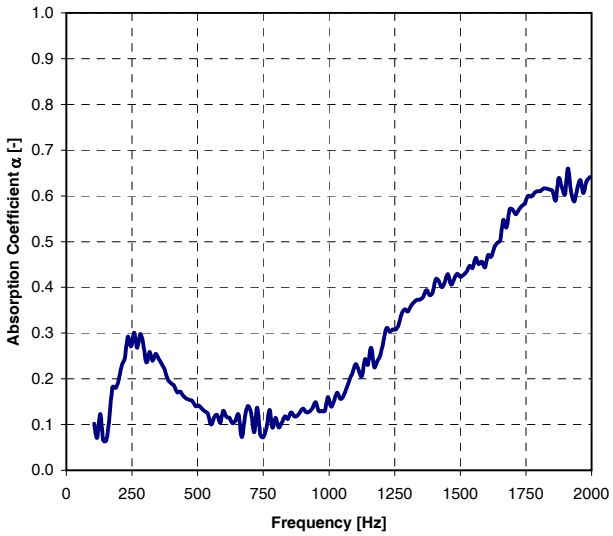
Sound Absorption

ISO 10534-1

Test Sample:	TWE043	
Code:	02022.TWE043	
Total height:	80	mm
Thickness Top Layer:	20-24	mm
Thickness Second Layer:	56-58	mm
Porosity:	11,8	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

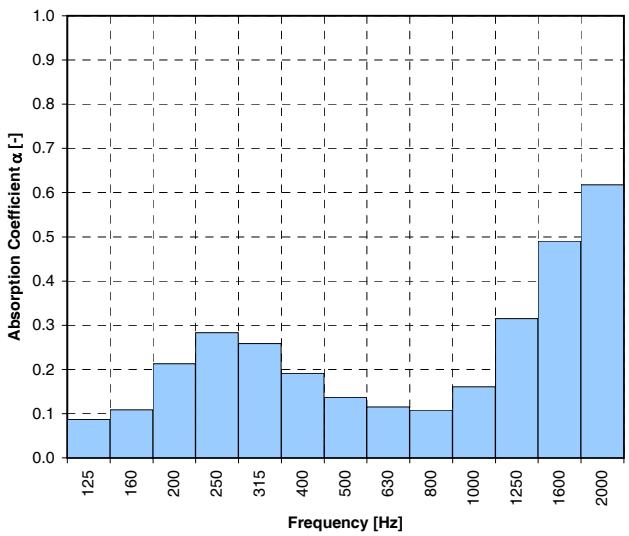
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.30

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.28

Sound Absorption of 02022.TWE043

M+P Raadgevende ingenieurs b.v.

Vught 073-6589050

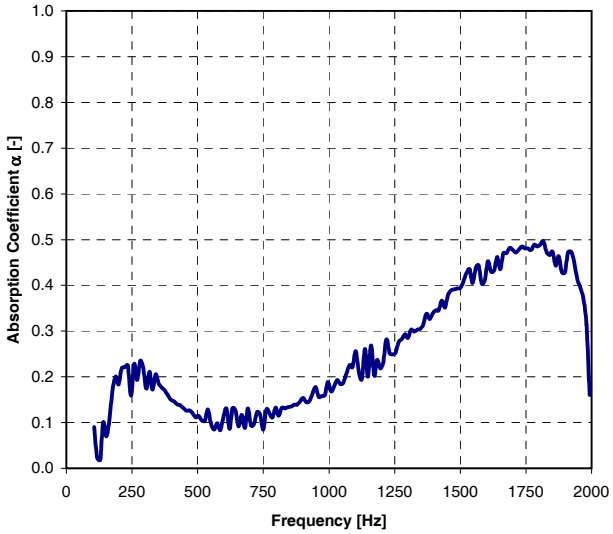
Sound Absorption

ISO 10534-1

Test Sample:	TWE045	
Code:	02022.TWE045	
Total height:	84	mm
Thickness Top Layer:	21-24	mm
Thickness Second Layer:	63	mm
Porosity:	11	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

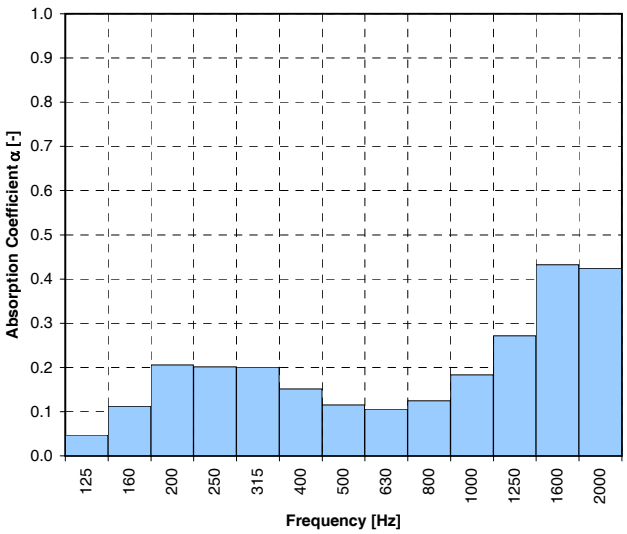
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	281 Hz
α_{max}	0.24

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.21

Sound Absorption of 02022.TWE045

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

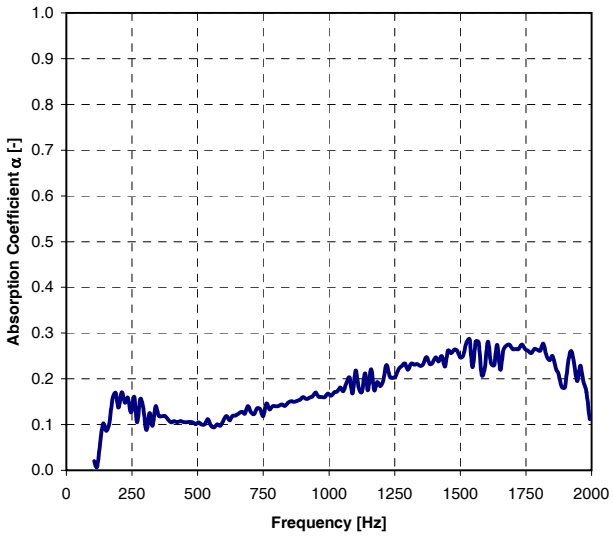
Sound Absorption

ISO 10534-1

Test Sample:	TWE046	
Code:	02022.TWE046	
Total height:	88	mm
Thickness Top Layer:	30-32	mm
Thickness Second Layer:	54-55	mm
Porosity:	12,1	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

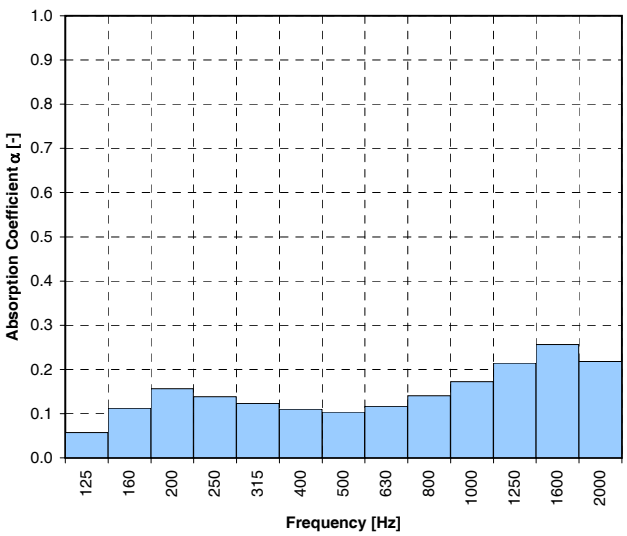
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	211 Hz
α_{max}	0.17

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.16

Sound Absorption of 02022.TWE046

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

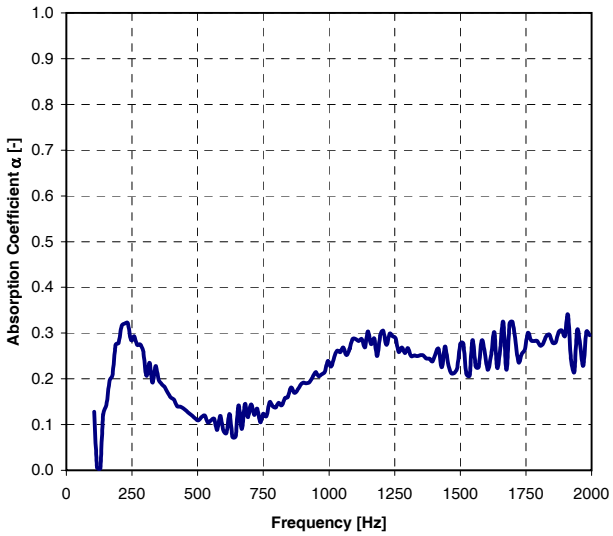
Sound Absorption

ISO 10534-1

Test Sample:	TWE048	
Code:	02022.TWE048	
Total height:	90	mm
Thickness Top Layer:	30-32	mm
Thickness Second Layer:	58-60	mm
Porosity:	14,9	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

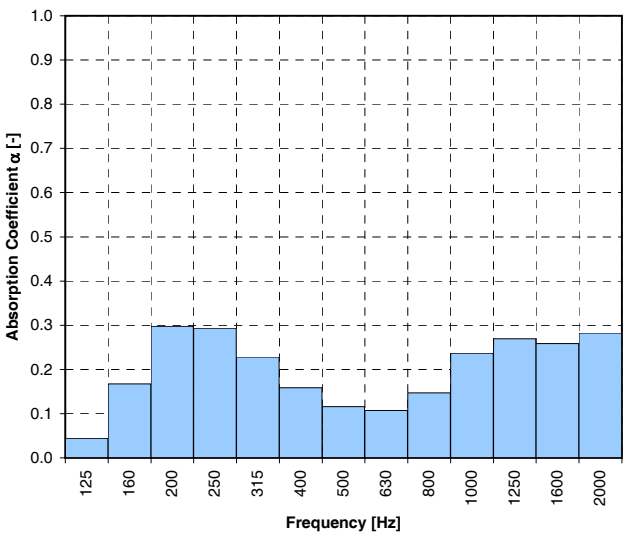
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	234 Hz
α_{max}	0.32

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.30

Sound Absorption of 02022.TWE048

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

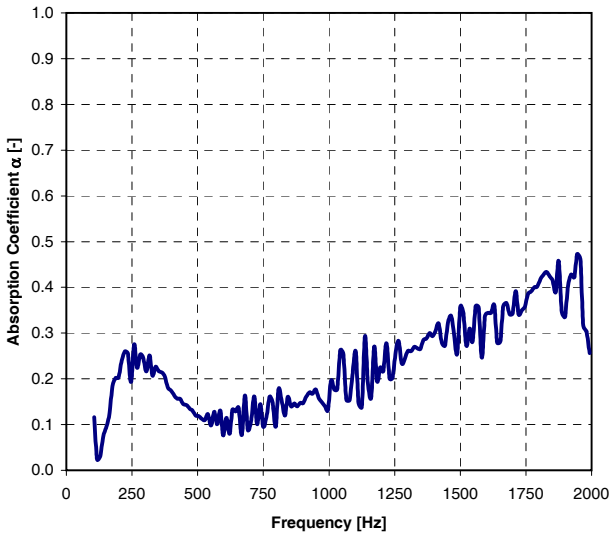
Sound Absorption

ISO 10534-1

Test Sample:	TWE049	
Code:	02022.TWE049	
Total height:	79	mm
Thickness Top Layer:	18-23	mm
Thickness Second Layer:	57-62	mm
Porosity:	8,5	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

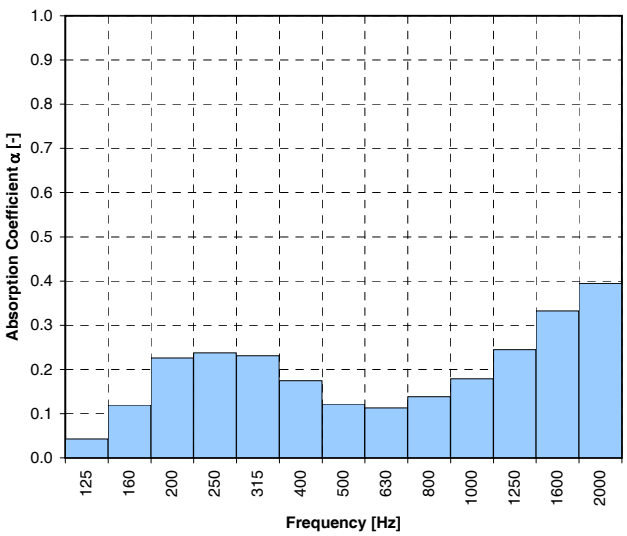
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.28

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.24

Sound Absorption of 02022.TWE049

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

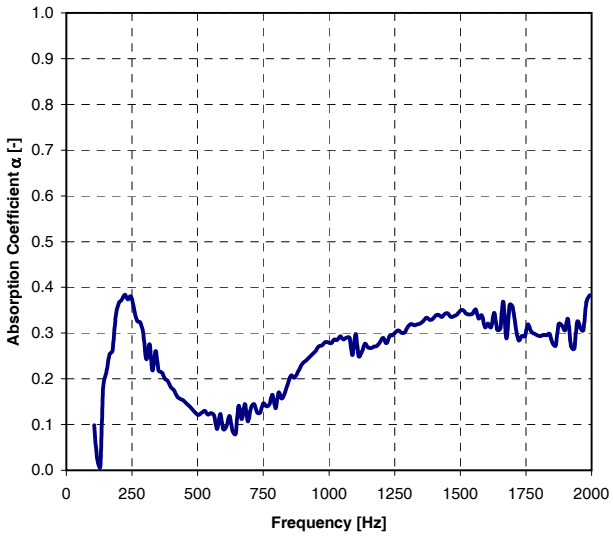
Sound Absorption

ISO 10534-1

Test Sample:	TWE050	
Code:	02022.TWE050	
Total height:	93,6	mm
Thickness Top Layer:	30	mm
Thickness Second Layer:	62	mm
Porosity:	14,8	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

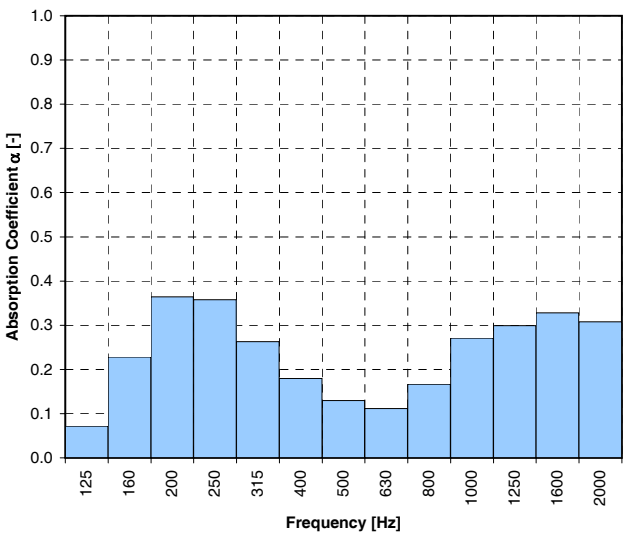
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	223 Hz
α_{max}	0.38

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.36

Sound Absorption of 02022.TWE050

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

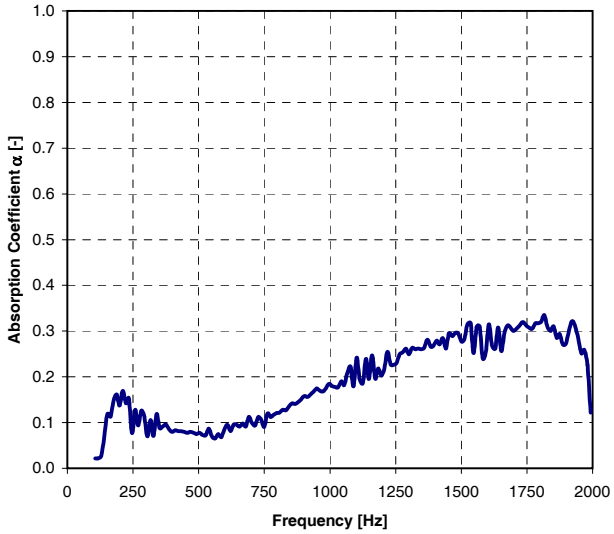
Sound Absorption

ISO 10534-1

Test Sample:	TWE052	
Code:	02022.TWE052	
Total height:	88,5	mm
Thickness Top Layer:	18-22	mm
Thickness Second Layer:	65-68	mm
Porosity:	8,7	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

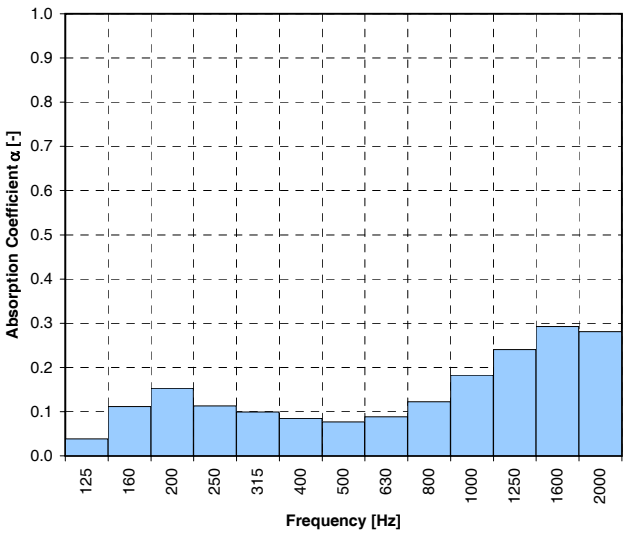
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	211 Hz
α_{max}	0.17

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.15

Sound Absorption of 02022.TWE052

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

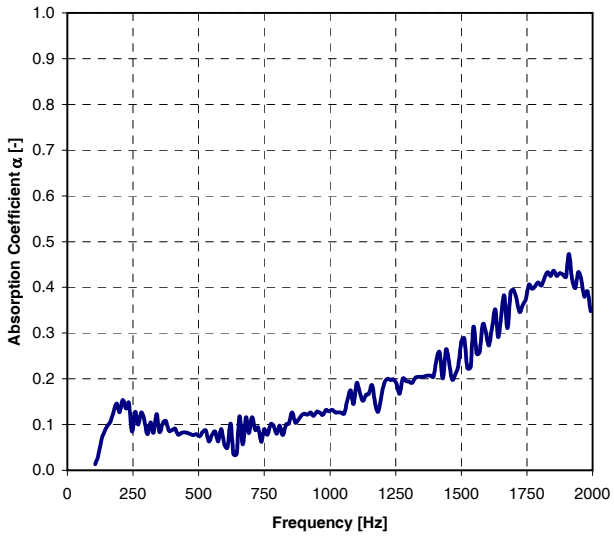
Sound Absorption

ISO 10534-1

Test Sample:	TWE056	
Code:	02022.TWE056	
Total height:	85,5	mm
Thickness Top Layer:	17-22	mm
Thickness Second Layer:	65-68	mm
Porosity:	11,1	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

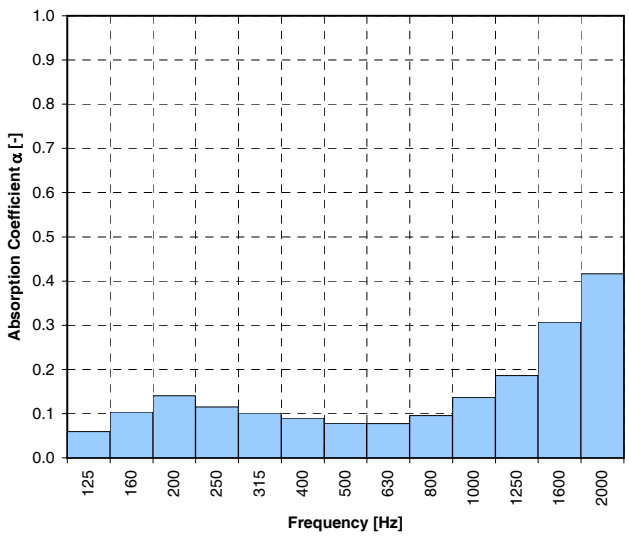
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	211 Hz
α_{max}	0.15

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	200 Hz
α_{max}	0.14

Sound Absorption of 02022.TWE056

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

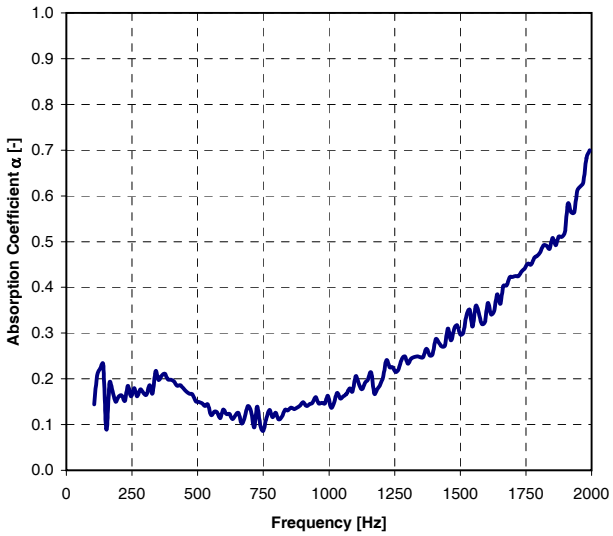
Sound Absorption

ISO 10534-1

Test Sample:	TWE061	
Code:	02022.TWE061	
Total height:	81	mm
Thickness Top Layer:	19-25	mm
Thickness Second Layer:	58-65	mm
Porosity:	9,3	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

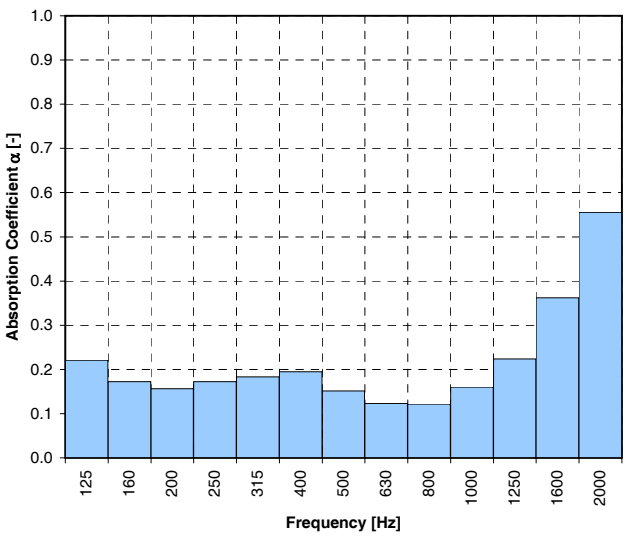
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	340 Hz
α_{max}	0.22

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	400 Hz
α_{max}	0.20

Sound Absorption of 02022.TWE061

M+P Raadgevende ingenieurs b.v.
Vught 073-6589050

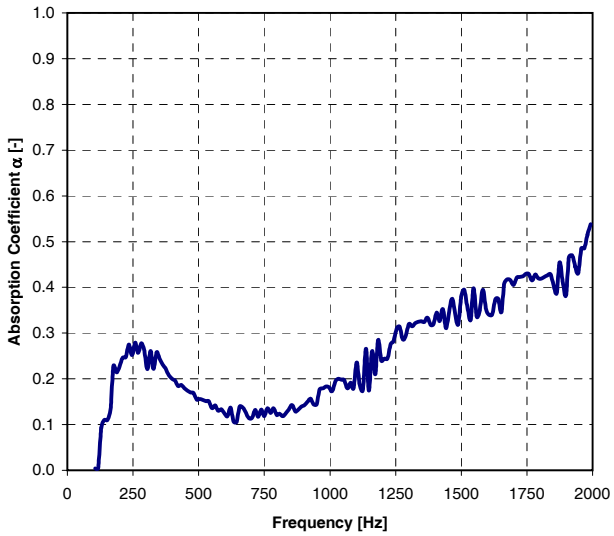
Sound Absorption

ISO 10534-1

Test Sample:	TWE066	
Code:	02022.TWE066	
Total height:	75	mm
Thickness Top Layer:	17-23	mm
Thickness Second Layer:	52-56	mm
Porosity:	10,1	%
Date:	26-2-2004	
Temperature:	20	°C
Air Pressure:	1013	hPa

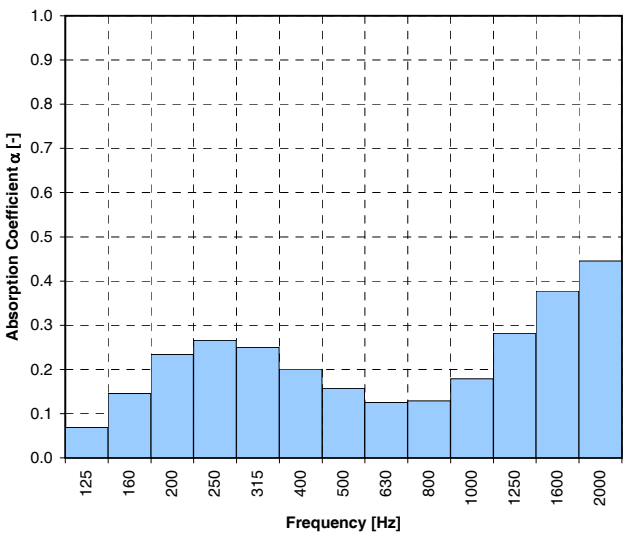
MEASUREMENT RESULTS

FULL FREQUENCY RANGE



First absorption maximum	
$f_{\alpha,max}$	258 Hz
α_{max}	0.28

1 / 3 OCTAVE BANDS



First absorption maximum	
$f_{\alpha,max}$	250 Hz
α_{max}	0.27

Sound Absorption of 02022.TWE066

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